

VIRGINIA DEPARTMENT OF TRANSPORTATION

TRAFFIC ENGINEERING DIVISION

INSTRUCTIONAL & INFORMATIONAL MEMORANDUM

GENERAL SUBJECT: Barrier Systems	NUMBER: IIM-TE-367.1
	SUPERSEDES: TE-367.0
SPECIFIC SUBJECT: Guardrail System Spot Repair Damage Condition Ratings and Repair Strategies for Damaged Guardrail Systems	DATE: April 9, 2019
	SUNSET DATE: None
APPROVAL: /original signed by/ Raymond J. Khoury, P.E. State Traffic Engineer Richmond, VA April 9, 2019	

Changes are shaded

CURRENT REVISION

This memorandum was revised to include updates based on VDOT adoption of "Manual for Assessing Safety Hardware" (MASH) performance criteria. Organizational improvements were also made.

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PURPOSE AND NEED

Guardrail systems are roadside safety features for redirecting errant vehicles from a dangerous path. The term, “guardrail system”, refers to typical guardrail sections such as W-beam and cable barriers, transition areas, and end treatments. When guardrail systems are damaged, they may not be able to fully perform their intended functions to protect errant vehicles and sometimes may become hazards themselves. The repair, replacement, and/or upgrade of damaged guardrail systems are critical to the safety of the traveling public. Therefore, periodic reviews of in-service guardrail systems should be conducted as necessary to help ensure they perform their intended functions and provide timely upgrade(s) and repair(s) as needed. These reviews and associated decisions **shall** be conducted by personnel who have successfully completed VDOT’s Guardrail Installation Training (GRIT) course and hold a current certification.

Attachments A and B provide guidance for determining damage condition ratings and repair strategies for damaged guardrail systems.

RELATED POLICY GUIDANCE

This memo **shall** be used in conjunction with the most recently approved version of [TE Memo-366](#), which provides guidance on determining the functional condition ratings and strategies to upgrade existing guardrail systems. A functional condition assessment of the entire damaged guardrail run is recommended prior to assessing the damage condition rating in order to determine whether the entire guardrail run should be replaced in lieu of planning spot repairs.

Refer to [Appendix I](#) and [Appendix J](#) of the [VDOT Road Design Manual](#) for guidance and guidelines on upgrading existing guardrail systems associated with construction and major rehabilitation projects. Refer to the [VDOT’s GRIT Manual](#) for general information on the installation, replacement and repair of guardrail systems. All new guardrail installations **shall** comply with current [VDOT Road and Bridge Standards](#) and [VDOT Road and Bridge Specifications](#).

A systematic methodology to periodically collect physical inventory information and functional condition information will be established under a separate document.

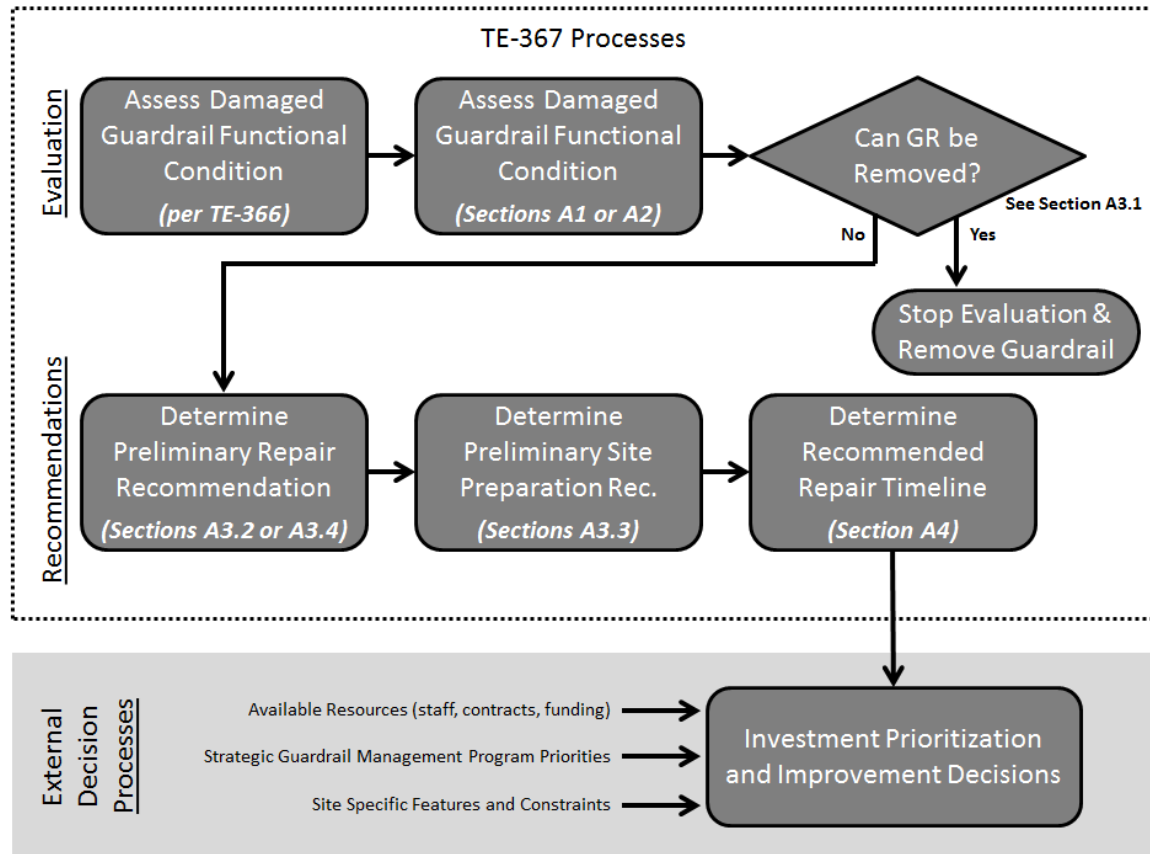
The determination of repair strategies for damaged guardrail shall be made in consideration of an evaluation that considers several factors. Each factor is to be reviewed independently and then collectively/holistically to formulate the best decision plan that balances the upgrade of existing guardrail systems to meet current VDOT standards, the damage severity, and road user risk exposure to a damaged guardrail terminal that may or may not be capable of serving its intended function.

The general process for damaged guardrail evaluation and determination of repair strategies should generally follow the below process (also depicted in Figure 1):

1. Evaluate and determine the functional condition rating of the damaged guardrail system using the protocol in the most recently approved version of TE-366.
2. Evaluate and determine the damage condition rating of the damaged guardrail system using the protocol in Section A1 or A2, as applicable.
3. Evaluate the site for potential elimination of the guardrail system per Section A3.1. If guardrail can be eliminated, STOP evaluation and remove the guardrail system rather than repair it.
4. Determine the recommended repair strategies per Section A3.2 or A3.4.
5. Determine the recommended site preparation consideration per Section A3.3.

6. Determine the recommended repair timeline per Section A4.
7. Make final determination of the repair strategy in consideration of:
 - available resources (staffing, contracts, etc.)
 - budgets,
 - site specific features/constraints,
 - recommendations from steps 4, 5, and 6.

Figure 1 – Guardrail Evaluation and Repair Strategy Determination Flowchart



DEFINITIONS

For the purpose of this policy, following are the definitions of the various guardrail components referred to throughout this TE Memorandum:

Guardrail Section: Individual segment of guardrail with a consistent cross section such as:

- End treatment
- Transition area, or
- W-beam, cable, or other segments (which could include multiple manufactured panels which together make one guardrail section)

Guardrail Run: A continuous length of guardrail excluding the end treatments.

Guardrail System: A complete functional guardrail in its entirety, including all guardrail sections, cables, beams, posts, block-outs, and hardware.

End Treatment: The terminal section at either end of a guardrail run. Classified as either run-on or run-off.

ATTACHMENT A: Damage Conditions of Guardrail Systems

The severity of the damage to a portion of the guardrail system is measured using damage condition ratings. A functional condition assessment of the entire damaged guardrail run is recommended prior to assessing the damage condition rating in order to determine whether the entire guardrail run should be replaced in lieu of planning spot repairs.

Section A1 below is informational only and describes the general description of the four categories of condition rating. Subsequently, Section A2 provides more detailed criteria for each guardrail system type.

Section A1 – General Guardrail Damage Condition Ratings

The following provides general criteria to determine the damage condition ratings of guardrail systems. The general criteria should only be used for scenarios which are not address in the detailed criteria in Section A2 or Attachment B.

No Damage: No visible damage to the guardrail system is observed.

Minor: Damage to the guardrail system is minor. Although the guardrail system may not be aesthetically pleasing, it will perform its intended function.

Moderate: Damage to the guardrail system is obvious but the guardrail system still maintains its structural integrity and will work for most traffic conditions.

Severe: Damage to the guardrail system is so severe that the guardrail system no longer functions as designed or has become a hazard itself to the traveling public.

Section A2 – Detailed Criteria for Major Types of Guardrail Systems

Detailed criteria to determine the damage condition ratings of each guardrail element for systems such as W-beam guardrail and end treatments are listed in Attachment B. A brief damage condition summary for the major guardrail types is as follows:

A2.1 – W-Beam Guardrail Systems

No Damage: No visible damage to the guardrail system is observed.

Minor: Less than 6 inches of post or rail deflection, no missing posts and damage limited to less than 60% of the guardrail run.

Moderate: 6 to 9 inches of post or rail deflection, no missing posts and damage limited to less than 60% of the guardrail run.

Severe: Greater than 9 inches of post or rail deflection, missing or broken posts, 60% or more of the guardrail run is damaged, or any damage to an end treatment.

Note: Weathering Steel (COR-TEN or ASTM A588) Guardrail Systems are no longer acceptable for use in most situations due to the potential for premature material failure from excessive rust. Except in rare situations, as discussed in

IIM-TE-367.1 – Attachment A

Damage Conditions of Guardrail Systems

TE-366, any damage to the weathering steel guardrail system **shall** be rated no better than moderate.

A2.2 – Cable Systems

Severe: Any damage to cable guardrail or terminal end treatments.

Section A3 – Repair, Replacement, and Upgrade Strategies

To determine the repair strategies and timelines for damaged guardrail systems, factors such as the functional condition rating of the entire run of the guardrail systems, damage condition ratings, road functional classification, etc. should be considered. The following section provides detailed guidance on the repair strategies and timelines for damaged guardrail systems.

A3.1 – Elimination of Damaged Guardrail

Roadside barriers are hazards. Prior to deciding how and when to repair the damaged guardrail system, the feasibility of removing the damaged guardrail run should be explored.

- If no hazard can be identified behind the existing guardrail, the existing guardrail system should be removed.
- If there is an existing hazard behind the existing guardrail and it can be removed or relocated for a reasonable cost, effort should be made to do so and the existing guardrail run should be removed.

The decision to eliminate an existing run of guardrail due to the lack of an existing hazard or the removal of an existing hazard **shall** be made by someone who has successfully completed VDOT's GRIT course and holds a current certification.

A3.2 – General Repair, Replacement, and Upgrade Strategies

Damaged guardrail systems should be repaired, replaced, or upgraded to the latest VDOT standards whenever possible. Repairs must be prioritized based on the damage severity and remaining functionality of the damaged guardrail systems. All other factors being equal, repairing and upgrading damaged sections of guardrail should be given priority over upgrading substandard but undamaged guardrail.

When determining the proper repair strategies of damaged guardrail systems, the functional condition rating of the entire run should be accounted for and used to determine the most cost effective option.

Section A3.4 provides specific guardrail repair, replacement, and upgrade strategies for standard VDOT guardrail applications. For situations not addressed in Section A3.4, the repair strategy determination should be guided by the following:

- For damaged guardrail systems with a **functional rating of Grade C or**

IIM-TE-367.1 – Attachment A

Damage Conditions of Guardrail Systems

D, the option of upgrading the entire run of guardrail in lieu of repairing only the damaged portion **shall** be considered.

- Where 60% or more of the length of the entire guardrail run is damaged, the entire run of the guardrail system should be upgraded.
- When an entire run of guardrail needs to be upgraded, all barrier and terminal systems **shall** be replaced with systems meeting the **current** VDOT standards and specifications. .

A3.3 – Site Preparation Considerations

Site preparation work for damaged guardrail terminals requiring an upgrade to current MASH/NCHRP-350 criteria is categorized as either minor, moderate, major, or not feasible and are defined as follows:

- **Minor Site Preparation:** Minimal action required in order to install terminal.
 - MGS-2 terminals can reasonably be installed by contractors familiar with straight-forward guardrail installation methods (i.e. in-kind guardrail replacements) with minimal modification to the site.
 - Existing shoulders likely meet or exceed GR-MGS2 shoulder-slope requirements; if not, shoulders may be modified to meet standard by placement of up to 4 inches of stone/aggregate.
- **Moderate Site Preparation:** Modest action required in order to install terminal.
 - Terminal installation will likely require additional means beyond what is typically seen for in-kind replacements, including additional construction equipment (front-end loaders, skid-steers, etc.).
 - Placement of surplus fill-material, in addition to stone/aggregate, will be necessary to provide shoulder slopes and widths in accordance with GR-MGS2 standards.
- **Major Site Preparation:** Significant action required in order to install terminal.
 - Existing shoulders will require substantial modification, including in some cases the horizontal or vertical relocation of grass/paved ditches. Surplus fill-material placement, in union with other site modifications, will be necessary.
 - Additional engineering and design documentation is likely necessary to address site preparation requirements.
- **Not Feasible:** No actionable solution for the installation of a terminal meeting MASH standards can be provided at a reasonable cost or level of effort.
 - VDOT GR-MGS2 standards dictate that 6-foot site-preparation is desired, but that no less than 4-foot shall be provided. However, for the purposes of guardrail spot repairs, site preparation widths of less than 4-foot may be permissible per Section 8.3.3.2 “Adjacent Grading” of the AASHTO Roadside Design Guide at locations where achieving 4-foot site preparation may not be cost effective, such as on roadways with limited rights-of-way. In such cases, effort shall be made to achieve the greatest feasible site preparation width. Judgment should

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Damage Conditions of Guardrail Systems

be utilized when initiating site preparation work such that the repair of guardrail runs and/or terminals that are critical to the safety of the traveling public is not delayed as a result of effort to achieve standard site preparation criteria.

A3.4 – Specific Repair, Replacement, or Upgrade Strategies

Table A1 provides a summary of the specific strategies to repair or upgrade major guardrail types. Users of this table **shall** have successfully completed VDOT's GRIT course, maintain a current certification and should use engineering judgment to determine the best strategy for each specific case. When the rail transition length (either to or from the existing guardrail run or terminal to the proposed upgrade or replacement standard) overlaps with the pay limits of an existing terminal that is not damaged, that terminal should be upgraded using the guidance in Table A1.

Prior to replacing a damaged terminal, the existing location of the terminal should be evaluated as to whether the guardrail meets length of need as outlined in the current [VDOT GRIT Manual](#). If the existing section needs to be extended and the terminal replaced further upstream in order to meet minimum length of need, this should be implemented where practical. The need for the roadside safety feature to be replaced in a timely manner should be considered in this decision. If existing conditions make this impractical (e.g., restricted R/W, utility conflicts, or other physical roadside limitations), then replacement in the current location is acceptable in order to return the roadside safety feature to functional working condition in a more appropriate timeline.

IIM-TE-367.1 – Attachment A

Damage Conditions of Guardrail Systems

Table A1 – Specific Guardrail Repair, Replacement, or Upgrade Strategies

Damaged or Impacted Rail/Terminal Type	Repair, Replace, or Upgrade Damaged Action	Notes
GR-1		
	Replace entire run with GR-MGS1 and GR-MGS2/MGS3.	
GR-2		
Run <200' Grade D	Replace entire run with GR-MGS1.	Install new run-on and/or run-off terminals if terminals are Grade C or D.
Run <200' Grade A, B, or C Damage >60% of length	Replace entire run with GR-MGS1.	Install new run-on and/or run-off terminals if terminals are Grade C or D.
Run <200' Grade A, B, or C Damage <60% of length	Repair damage run section with GR-2.	Remaining undamaged segment should be scheduled for upgrading as part of VDOT's Strategic Guardrail Program Prioritization.
Run >200' Damage <60% length	Repair damage with GR-2.	Remaining undamaged segment should be scheduled for upgrading as part of VDOT's Strategic Guardrail Program Prioritization.
Run >200' Damage >60% length	Replace entire run with GR-MGS1	Install new run-on and/or run-off terminals if terminals are Grade C or D.
GR-3		
	Upgrade to MGS system if site conditions appropriate. If site conditions do not allow for MGS system, replace damaged system with GR-3.	

IIM-TE-367.1 – Attachment A

Damage Conditions of Guardrail Systems

**Table A1 – Specific Guardrail Repair, Replacement, or Upgrade Strategies
(continued)**

Damaged or Impacted Rail/Terminal Type	Repair, Replace, or Upgrade Damaged Action	Notes
GR-4, GR-FOA, BR-GR Attachments		
	Replace with standard GR-FOA or current BR-GR design.	
GR-5		
	<p>Replace with GR-MGS2 if site conditions appropriate. If site conditions do not allow for MGS system, replace with GR-7.</p> <p>Consider eliminating terminal:</p> <ul style="list-style-type: none"> If space between two runs of GR is approximately 200' consider closing the gap. If cut slope meeting GR-6 requirements is within approximately 200' of terminal, consider extending rail and replace with GR-6. 	<p>Include GR-MGS4 transition if connecting new GR-MGS2 to GR-2.</p> <p>There is currently no MASH equivalent of the GR-7 for use by VDOT. Site must provide 75' of clear run-out path for GR-7.</p>
GR-6		
	<ul style="list-style-type: none"> Replace with GR-6 (if standard can be met) otherwise replace with GR-MGS2 (if site conditions appropriate) or GR-7 (if site conditions do not allow for MGS system). 	<p>Include GR-MGS4 transition if connecting new GR-MGS2 to GR-2.</p> <p>There is currently no MASH equivalent of the GR-7 for use by VDOT. Site must provide 75' of clear run-out path for GR-7.</p>
GR-7		
	<p>Replace with GR-MGS2 if site conditions appropriate. If site conditions do not allow for MGS system, replace with GR-7 (if standard can be met).</p> <p>Consider eliminating terminal:</p> <ul style="list-style-type: none"> If space between two runs of GR is approximately 200' consider closing the gap. If cut slope meeting GR-6 requirements is within approximately 200' of terminal, consider extending rail and replace with GR-6. 	<p>Include GR-MGS4 transition if connecting new GR-MGS2 to GR-2.</p> <p>There is currently no MASH equivalent of the GR-7 for use by VDOT. Site must provide 75' of clear run-out path for GR-7.</p>

IIM-TE-367.1 – Attachment A

Damage Conditions of Guardrail Systems

**Table A1 – Specific Guardrail Repair, Replacement, or Upgrade Strategies
(continued)**

Damaged or Impacted Rail/Terminal Type	Repair, Replace or Upgrade Action	Notes
GR-8 NCHRP-350 TL-3		
Run <200'	Replace entire run with GR-MGS1 and GR-MGS2/MGS3.	
Run >200' Damage <60% length	Repair damage with GR-8 NCHRP-350 TL-3.	
Run >200' Damage >60% length	Replace entire run with GR-MGS1 and GR-MGS2/MGS3.	
GR-8, Non-NCHRP-350 TL-3		
Run <500'	Replace entire run with GR-MGS1 and GR-MGS2/MGS3.	
Run >500' Damage <60% length	Consider replacing entire run with GR-MGS1 and GR-MGS2/MGS3. If entire run is not replaced, repair damage with GR-8 NCHRP-350 TL-3.	
Run >500' Damage >60% length	Replace entire run with GR-MGS1 and GR-MGS2/MGS3.	
GR-9		
	Replace with GR-MGS2. Consider eliminating terminal: <ul style="list-style-type: none"> If space between two runs of GR is approximately 200' consider closing the gap. If cut slope meeting GR-6 requirements is within approximately 200' of terminal, consider extending rail and replace with GR-6. 	Include GR-MGS4 transition if connecting new GR-MGS2 to GR-2.
GR-11		
	Replace with GR-MGS3 if connecting to GR-MGS1. Replace with GR-11 if connecting to GR-2.	
GR-MGS1		
	Repair damage with GR-MGS1, consider replacing entire run with GR-MGS1 based on judgement.	Install new run-on and/or run-off terminals if terminals are Grade C or D.
GR-MGS2		
	Replace with GR-MGS2	
GR-MGS3		
	Replace with GR-MGS3	

IIM-TE-367.1 – Attachment A Damage Conditions of Guardrail Systems

Section A4 – Repair Timelines

Unless otherwise noted, the general recommended timelines to repair damaged guardrail systems are as follows:

- **Minor:** Immediate repair is not required. Repair or upgrade should be scheduled as funding becomes available.
- **Moderate:** Damaged section should be scheduled for repair or upgrade within a reasonable time.
- **Severe:** Damaged section **shall** be scheduled for repair or upgrade as soon as possible. Warning devices should be installed immediately and remain in place until the repair or upgrade is made.

Traffic Engineering Division will work with District stakeholders to determine feasible timelines guidance for guardrail system repair for each roadway classification.

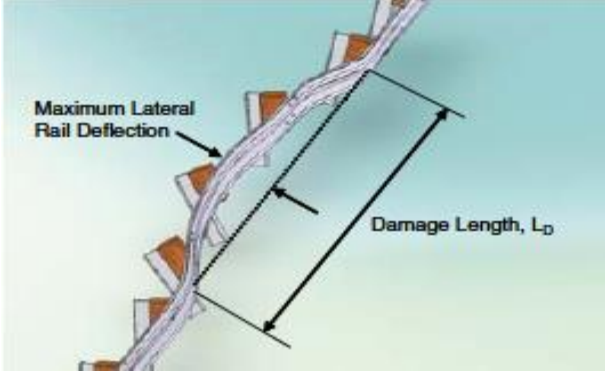
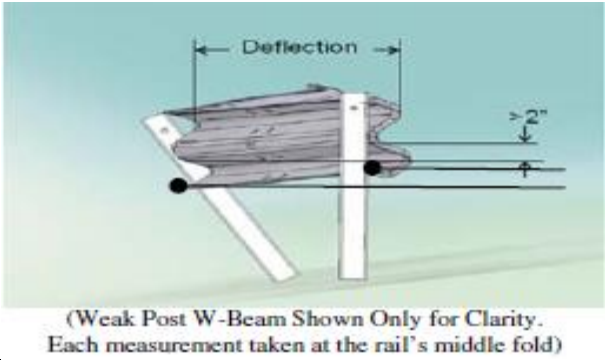

IIM-TE-367.1 – Attachment B

Detailed Damage Condition Ratings Criteria

ATTACHMENT B: Detailed Damage Condition Ratings Criteria

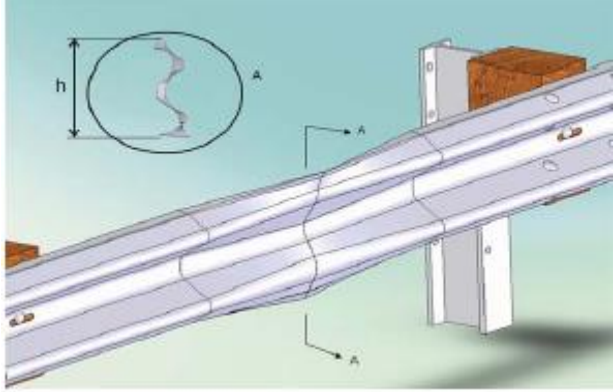
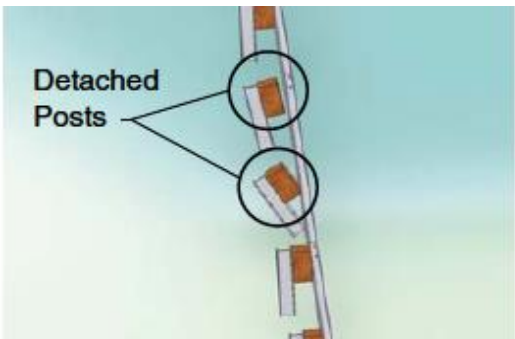
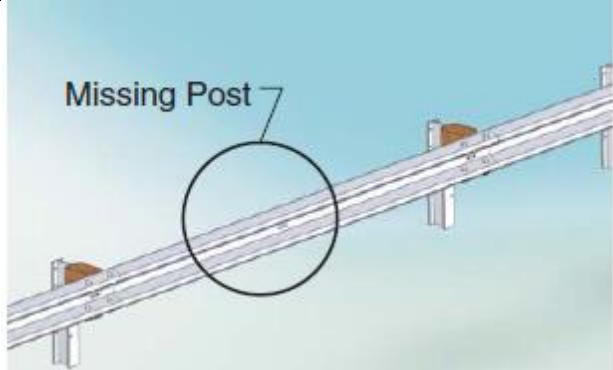
Section B1 – W-Beam Barrier System

Table B1 – Detailed W-Beam Barrier Damage Condition Rating Criteria

Damage Mode	Extent of Damage (One or more of the following thresholds)	Damage Condition Rating (No better than)	Measurement
Post and Rail Deflection	More than 9 in. of lateral deflection anywhere over a 25-ft length of rail	Severe	 
	Top of rail height 2 or more inches lower than original top of rail height		
	6-9 in. lateral deflection anywhere over a 25-ft length of rail	Moderate	
	Less than 6 in. of lateral deflection over a 25-ft length of rail	Minor	
Rail Deflection Only	6-9 in. of lateral deflection between any two adjacent posts	Moderate	
	<p>Note: For deflection over 9 in., use post/rail deflection guidelines.</p> <p>Less than 6 in. of lateral deflection between any two adjacent posts</p>	Minor	

IIM-TE-367.1 – Attachment B
Detailed Damage Condition Ratings Criteria

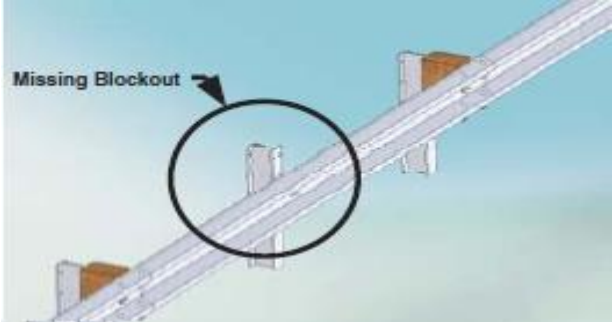
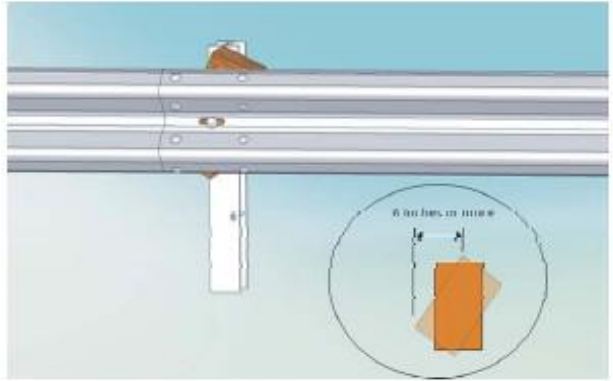
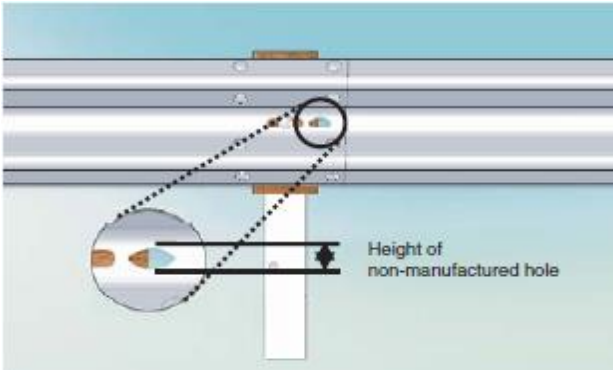
Table B1 – Detailed W-Beam Barrier Damage Condition Rating Criteria (continued)

Damage Mode	Extent of Damage (One or more of the following thresholds)	Damage Condition Rating (No better than)	Measurement
Rail Flattening	Rail cross-section height is more than 17 in. (such as may occur if the rail is flattened)	Moderate	
	Rail cross-section height is less than 9 in. (such as dent to the top edge)	Minor	
Posts Separated from Rail	2 or more posts with blackout attached with a post/rail separation less than 3 in.	Moderate	 <p><u>Note:</u></p> <ol style="list-style-type: none"> 1. If the blackout is not firmly attached to the post, use the missing blackout guidelines. 2. Damage should also be evaluated against post/rail deflection guidelines.
	1 or more posts with a post/rail separation which exceeds 3 in.	Minor	
Missing/ Broken Posts	1 or more posts: <ul style="list-style-type: none"> • Missing • Cracked across the grain • Broken • Rotted • With metal tears 	Severe	

IIM-TE-367.1 – Attachment B

Detailed Damage Condition Ratings Criteria

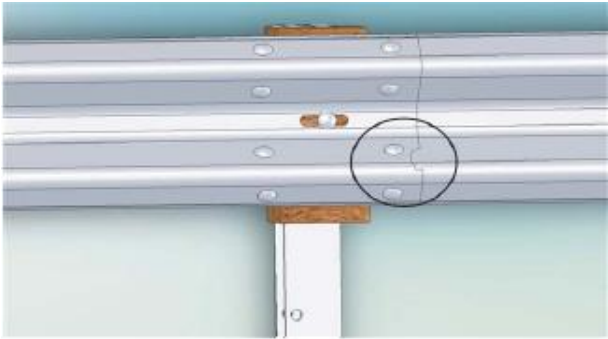
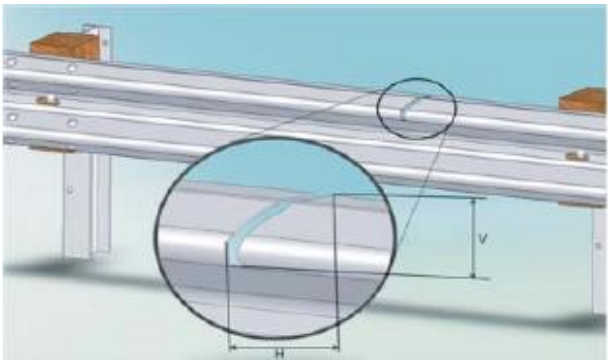
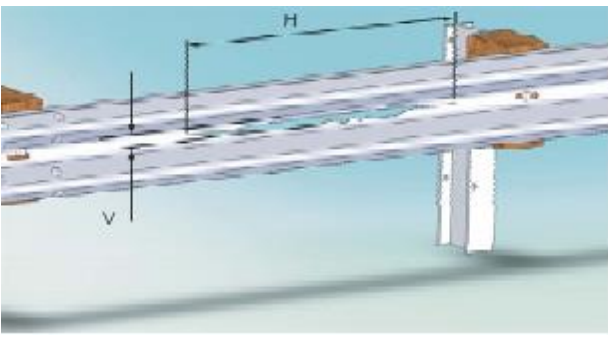
Table B1 – Detailed W-Beam Barrier Damage Condition Rating Criteria (continued)

Damage Mode	Extent of Damage (One or more of the following thresholds)	Damage Condition Rating (No better than)	Measurement
Missing Blockout	Any blockouts: <ul style="list-style-type: none"> Missing Cracked across the grain Cracked from top or bottom of blockout through post bolt hole Rotted 	Moderate	
Twisted Blockouts	Any misaligned blockouts where the top edge of the block is 6 in. or more from the bottom edge Note: Repair of twisted blockouts are relatively quick and inexpensive	Minor	
Non-Manufactured hole (Such as crash induced hole, lug-nut damage or holes rusted-through the rail)	More than 2 holes with a height less than 1 inch on a 12.5-ft length of rail	Severe	
	Any holes with a height greater than 1 in. Any hole which intersects either the top or bottom edge of the rail	Moderate	
	1-2 holes with a height less than 1 in. on a 12.5-ft length of rail		

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Detailed Damage Condition Ratings Criteria

Table B1 – Detailed W-Beam Barrier Damage Condition Rating Criteria (continued)

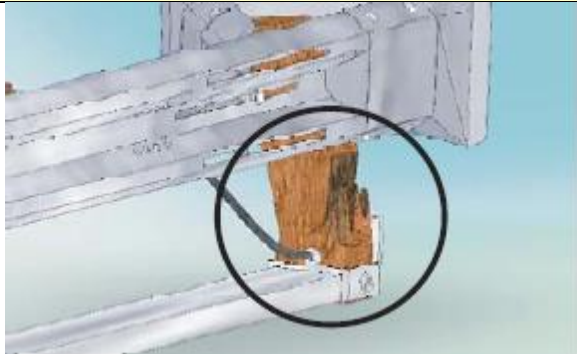
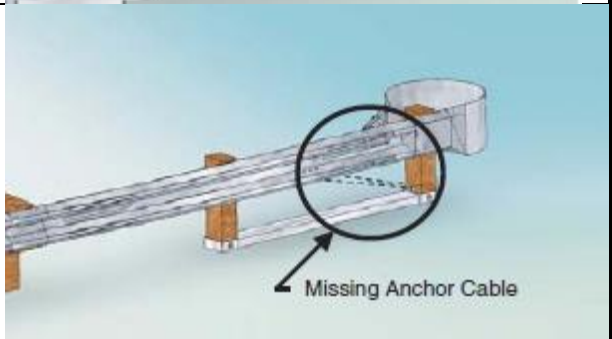
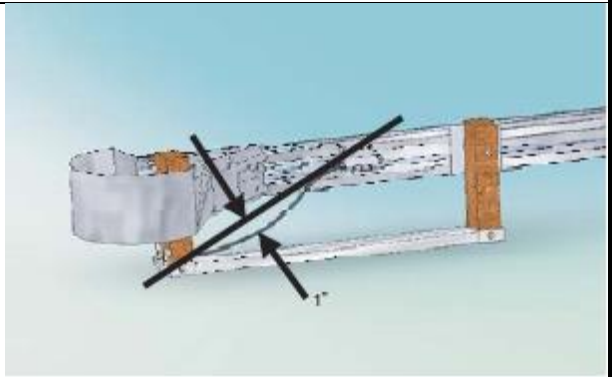
Damage Mode	Extent of Damage (One or more of the following thresholds)	Damage Condition Rating (No better than)	Measurement
Damage at a rail splice	More than 1 splice bolt: <ul style="list-style-type: none"> Missing Damaged Visibly missing any underlying rail Torn through rail 	Severe	
	1 splice bolt: <ul style="list-style-type: none"> Missing Damaged Visibly missing any underlying rail Torn through rail 	Moderate	
Vertical Tear	Any length vertical (transverse) tear	Severe	
Horizontal Tear	Horizontal (longitudinal) tears greater than 12 in. long or greater than 0.5 in. wide Note: for horizontal tears less than 12 in. in length or less than 0.5 in. in height, use the non-manufactured holes guidelines.	Moderate	

IIM-TE-367.1 – Attachment B

Detailed Damage Condition Ratings Criteria

Section B2 – End Beam Treatments

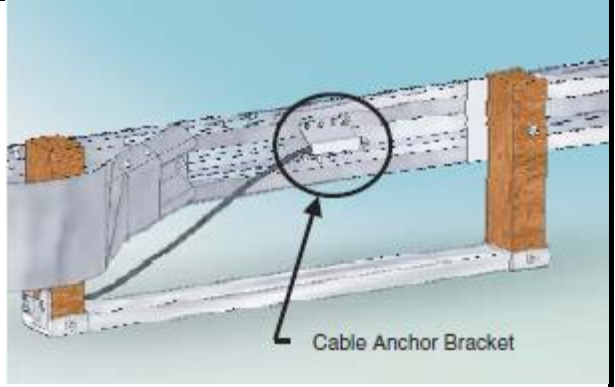
Table B2 – Detailed End Treatment Damage Condition Rating Criteria

Damage Mode	Extent of Damage (One or more of the following thresholds)	Damage Condition Rating (No better than)	Measurement
Damaged End Post	Not functional (sheared, rotted, cracked across the grain)	Severe	
Anchor Cable	Missing	Severe	
Anchor Cable	More than 1 in. of movement when pulled up by hand	Severe	

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Detailed Damage Condition Ratings Criteria

Table B2 – Detailed End Treatment Damage Condition Rating Criteria (continued)

Damage Mode	Extent of Damage (One or more of the following thresholds)	Damage Condition Rating (No better than)	Measurement
Cable Anchor Bracket	Loose or not firmly seated in rail	Moderate	
Stub Height	Height which exceeds 4 in.	Moderate	